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WASTE STABILIZATION PONDS

A STATEMENT OF COOPERATIVE STUDIES IN PROGRESS BY THE PUBLIC HEALTH SERVICE

ROBERT A. TAFT SANITARY ENGINEERING CENTER
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Waste stabilization ponds for treating raw sewage are used in smaller municipalities where provision of conventional treatment is often a financial burden. This study has three main parts: (1) collection and analysis of basic data on existing installations; (2) field studies of selected ponds for variability in design, loading and operation; (3) controlled studies on experimental units for the purpose of obtaining fundamental knowledge prerequisite to development of basic design and operation formulations and criteria.

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IN PROGRESS BY

THE

PUBLIC HEALTH SERVICE

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
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Introduction

Waste stabilization ponds for treating raw sewage have become very popular among the smaller municipalities where provision of conventional treatment oftentimes is a great financial burden. The number of communities in the northern plains States now using such facilities as the sole mode of treatment has increased considerably during the past several years to more than 100. In the southwest, and elsewhere to a limited extent, basically similar "oxidation ponds" are commonly used as a form of secondary or tertiary treatment. The number of such ponds in the Southwest is more than 250.

The northern plains type, frequently referred to as "sewage lagoons", are shallow ponds averaging about four feet deep and of such area as to provide one acre for each 100 persons in the population. Typically they range in cost from $4.50 to $20.00 per capita which is substantially less than the cost of conventional treatment facilities for towns of 300 to 2000 population. Some of the ponds used in the Southwest are loaded at considerably greater rates.

Basically, the stabilization process consists largely of the interactions of bacteria and algae. The bacteria digest and oxidize the constituents of sewage and render it innocuous. The algae utilize CO_2 and NH_3 resulting from bacterial action and, through photosynthesis, produce surplus oxygen needed for aerobic bacterial action. This organism inter-action has been called "algae symbiosis". During a detention period ranging upward from 175 days, the objectionable characteristics of sewage largely disappear.

Until recently, the use of such ponds as sole and permanent sewage treatment facilities generally has been looked upon with disfavor as poor engineering practice. Now, the great upsurge of interest in their use at many localities throughout the country emphasizes the need for new knowledge on the subject. Specifically, there is need for more precise information on the stabilization process, evaluation of the possible health hazards involved, and criteria for their design, construction, operation and maintenance.

In response to a resolution made by the 1954 Conference of State and Territorial Health Officers and requests from the State Water Pollution Control Agencies in the Missouri Basin, the Public Health Service has undertaken a cooperative study of waste stabilization ponds.

The study has three main parts. They are: (1) collection and analysis of basic data on existing installations; (2) field studies of selected ponds for variability in design, loading and operation; and (3) controlled studies on experimental units for the purpose of obtaining fundamental knowledge prerequisite to development of basic design and operation formulations and criteria.

Part 1. BASIC DATA COLLECTION

Basic data are being collected for waste stabilization ponds used as municipal or institutional facilities. Included in the collected information are data such as area and depth, population served, inflow and outflow rates, types and amounts of industrial wastes, soil characteristics, location with respect to habitation, climatological data and various operating experiences.

Data have been obtained for many of the facilities in the Dakotas, Oklahoma and Texas, and the collecting effort continues with extension to other parts of the country. In the interest of extending the coverage of the data collection, participation by State Health Departments in States that now have waste stabilization ponds treating municipal or institutional sewage is highly desirable. Standard data sheets will be supplied upon request.

Part 2. FIELD STUDIES

A. North and South Dakota

Five waste stabilization ponds in the northern plains area have been studied jointly with the State Health Departments in North and South Dakota. The objectives of this activity were to better define the stabilization mechanism, evaluate variables in design, loading and season, and point up the direction, method and objectives of controlled studies in experimental units.

The ponds for study were selected so as to provide a cross section of the types occurring in the general area. In size they ranged from 4 to 27 acres, in average depth from 1.2 to 5.4 feet, and in loading from 7 to 17 pounds of B.O.D. per acre per day. Two ponds had outlets; contents of the other three were lost totally by seepage and evaporation. Inlet structures varied from center to side locations. Four units consisted of a single cell, whereas one was composed of three connected in series.

Each of these facilities was studied intensively over a three-day period during the winter, spring, summer, and fall, starting in January 1955. Additional special studies were made also.

The information obtained thus far has not as yet been thoroughly analyzed and evaluated. The following general observations applicable to the northern plains area, however, may be of interest.

1. Reductions in coliform bacterial density (i. e. M. P. N.) were 99% more than 50% of the time and, except for one sampling period at two installations, were 95% or greater.

2. Concentration of B. O. D. was reduced by a minimum of 43% and a maximum of 98%.

3. In winter, total suspended matter was reduced 80% to 84%; in summer, because of algal production, it varied from 64% to an increase of 258%.

4. Sulfides were typically present under ice cover. In summer they were generally absent.

5. Populations of algae were low in winter and high in spring, summer, and fall. Scenedesmus was dominant in all ponds in winter; Euglena usually was dominant at some time during the warm period.

6. Soluble nitrogen and phosphorus concentrations were less in summer than winter, but carbon dioxide rather than these nutrients seemed to limit algal growth.

7. During calm weather, algae had vertical diurnal movements so that they concentrated at the surface during the day and were carried out with the overflow at diurnally varying rates.

8. Insect larvae, principally midges or bloodworms, which inhabit the bottom, apparently contributed little to the stabilization process.

9. Ice cover from 9 to 27 inches thick reduced light penetration to a value of 0.5% to 15% of that reaching the surface. During open water, the density of algal growth was largely responsibile for light absorption. Ninety-nine per cent of the incident light

was absorbed in the upper 11 to 24 inches. Because of this, the depth at which oxygen production was equal to biochemical utilization on a normal sunny day was in the neighborhood of 24 inches.

10. Because of tremendous photosynthetic production of oxygen, open water concentrations varied diurnally and ranged from 4 or 6 ppm at 4:00 a. m. to 38 ppm at 6:00 p. m. Much of the oxygen so produced escaped to the atmosphere. On some ponds, dissolved oxygen was exhausted during the night.

11. On calm days, the pond content became stratified so far as temperature, dissolved oxygen, pH, and algal density were concerned. Such stratification was not tenacious and disappeared readily at evening and during stormy weather.

12. Wind appeared to have little effect upon the stabilization process. Typically, the pond surface resisted wind-induced wave formation. Low surface tension, high algal density, and resistance to wave formation seemed to occur together.

B. Texas-Oklahoma

In addition to the Dakota studies, 34 waste stabilization ponds in Texas and Oklahoma were examined during the summer of 1955 by a Public Health Service engineer in company with district State Health Department engineers. At the time of the survey there were a total of 229 such installations in Texas and 36 in Oklahoma. These include playa lakes, dammed up ravines, and holding ponds as well as planned installations. Although no field studies were conducted, limited information similar in nature to that obtained in the Dakota studies was obtained concurrently with the basic data collection activities. Some of this information is summarized in the following paragraphs:

1. The area studied has a wide range in climatological characteristics. Annual average temperatures vary from 57° F. in the northwestern portion to 74° F. in the southern portion. Precipitation ranges from an annual average of 13" to 45". Evaporation ranges from a low of 40" annually in the central and eastern portions to 83" in the south central portion of the region.

2. In contrast to the Dakota facilities, only two of the 34 ponds examined received raw sewage; 20 received primary effluent; while 12 received the effluent from secondary or final treatment plants.

3. The number, size, and shape of cells varied widely, the smallest being 0.115 acres in area and the largest 27 acres in area (exclusive of Lake Mitchell at San Antonio). The smallest total pond area was 0.69 acres and the largest 85 acres. Most of the ponds were rectangular in plan while some were banana shaped, trapezoidal, or even triangular.

4. The most common depth approximated 3 feet, with some ranging from 4 to 5 feet. In a few of the "sewage lakes" the depths were much greater.

5. Based upon limited information, estimated B. O. D. loadings ranged from 12 to 225 pounds per acre per day. Corresponding retention times of total pond volume varied from 4 to 118 days. Twelve of the 34 installations received dairy plant, vegetable canning, citrus processing, or slaughter-house wastes.

6. Single cells were used at many locations, while one installation consisted of 20 cells. Seven of the installations visited utilized recirculation to provide better effluent or better pond conditions. Peters help in mind

7. Very few installations were subjected to such low temperatures as to cause extreme operating difficulties. Variations in rainfall were reported to have little effect on the ponds, except where significant amounts of surface drainage entered them. Several ponds had no outflow at the time of the survey.

8. With one or two exceptions, any odors present at the time of the examination appeared to be coming from the primary treatment units or channels carrying the sewage rather than from the ponds. High sulfate content of the water supply appeared to be associated with those one or two ponds producing appreciable odors.

9. Most of the operating difficulties of these waste stabilization ponds appeared to be associated with maintenance. Grass and weed growths occurred in several cases to the point of reducing the effective pond area and providing areas favorable to mosquito breeding. In one case, where weed and grass killers were used, the lack of vegetation on the dikes resulted in rather serious dike erosion from wave action.

10. In several instances, municipalities reported a reduction in odor nuisance problems following the construction of ponds.

Part 3. CONTROLLED STUDIES

It is the objective of the controlled studies to give better definition to the fundamental stabilization process and to evaluate the impact of natural and man-made factors so as to permit proper emphasis upon them in developing criteria for pond use.

Part 3 is currently in the planning and construction stages, and actual studies will be initiated in July 1956.

Groups of small ponds at two different locations will be used for controlled studies that will extend over a period of several years. These facilities will be used to determine critical loadings in the climatic and geographic areas concerned, most effective depth, and the benefits to be obtained from operational manipulations including recirculation, series and parallel arrangements.

Various other aspects of the waste stabilization pond problem are under study at a number of locations in this country and abroad. Notable are the fundamental and "high rate" pilot plant studies at the Sanitary Engineering Research Laboratory, University of California, and studies at the University of Texas relative to pond treatment of radioactive wastes. Several State Health Departments have one or two ponds under routine study. Similar studies in Sweden, Denmark, and Australia have been reported recently.

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